Paint scheme

Professor Gordon Smith, Principal Research Fellow with the WMG, University of Warwick, UK, describes a new process to reduce automotive paint shop costs.

Plastic paint shops require a large capital investment and have high energy requirements, with the associated carbon dioxide (CO_2) emissions and cost for manufacturers. Misubishi Motors' Mizushima plant's paint shop in Japan accounts for 60% of the entire facility's energy usage, and Ford reports that 70% of the total energy cost in itsassembly plants is used by the painting operations.

As well as running overheads there are also environmental costs. In 1997, General Motors reported that its most polluting manufacturing facility is the paint shop, responsible for over 43% of the company's total toxic releases. Alternative solvents, such as water, have been proposed, but these still require substantial drying energy and both volatiles and effluent have to be cleaned. The total CO_2 emissions saved by eliminating the automotive paint shop could be as high as 455t/day.

Altered images

Alternatives to painting the vehicle have been sought, for instance, car manufacturer De Lorean avoided the paint shop by the use of brushed stainless steel panels and the Smart car is clad with self-coloured plastic panels (see image below). However, a clear coat on the panels is needed to meet exterior durability.

Other methods to reduce the environmental impact of coating seek to eliminate the solvent by concentrating on solid paints, such as powder coats and films (in-mould decoration [IMD]). The automotive industry presents a difficult situation in its requirement to coat both metal and plastic to create a uniform aesthetic finish that is well matched on the surface of either material. This is not practical so a compromise needs to be made that allows a different coat regime for each material that can be appropriately designed into the assembled vehicle to produce an attractive finish.

The Smart car uses self-coloured plastic panels to reduce reliance on energy-intensive paint shops

Inspired choice

A new in-mould painting process, called 'IN-SPIRE', has been developed by researchers at the University of Warwick, UK. This coats injection mouldings with a thermoset paint during production. At present, the final coatings are thermoset polyesters, and mouldings consisting of an ABS substrate with this hard polyester coating are being developed for the mobile phone industry. However, it is likely to find application in many sectors, with the automotive industry a major beneficiary.

The energy usage of any new in-mould process needs to be compared against potential savings. IN-SPIRE paint is 100% solid in the form of a powder coat and contains no solvent, so no heat is needed to evaporate or treat emissions. Moulding the plastic component simultaneously with the paint injection should not demand additional energy.

Initial calculations using an average figure of 3.5kWh/1,000cuft = 866kWh/year, or an estimated energy usage of 1,237 standard cuft/min = 4.3kWh/day. This is extremely small in relation to a paint shop and the savings could be considerable.

The IN-SPIRE process is cost effective and environmentally friendly, capable of producing CO_2 savings in excess of 15,000kWh/day once the technology is fully exploited. It is likely to challenge current IMD technologies and be the process of choice, particularly for many single colour applications. This is where the IN-SPIRE process can best compete commercially.

IN-SPIRE has evolved from Granular Injection Paint Technology (GIPT) pioneered by the University of Warwick in collaboration with Rover Group, UK, in the 1990s. Granular Injection Paint Technology involves simultaneous co-injection of thermoplastic paint with a plastic. This method is especially good in comparison to in-mould films where more than one surface needs to be decorated (GIPT can cover the entire component), or where significant undercuts or other geometrical attributes cause problems. In-mould films require high capital outlay on a new proprietary moulding machine in addition to restriction of non-metallic paints. The IN-SPIRE process solves these shortcomings. It has –

- Low capital outlay – equipment is designed as an add-on module to any single injection moulding machine.
- Metallic paints – the random orientation of pigments by the IN-SPIRE process ensures no visible flow lines.

The process is unique in producing a thermoset coating on a thermoplastic moulding within a single injection cycle. The surface properties are therefore similar to those that would be produced by conventional thermoset painting processes.

Explosive shift

The patented technique (see schematic, above right) can be envisaged in the following steps – a powder coat is explosively sprayed into the mould cavity using a pressurised powder feed unit and by the gas blast, allowing the powder to evenly and randomly coat the cavity walls. The plastic substrate is injected using traditional injection moulding equipment, tooling and processes.

A heated tool softens the thermoset material, forming a film on the tool surface. The heat of the injected thermoplastic substrate cures the thermoset material before cooling. The cycle time of injection moulding depends on the cure reaction of the thermoset coating material. As injection moulding is carried out normally, IN-SPIRE does not affect the standard process parameters.

A fully painted component is produced from the mould. However, in contrast to previous developments in IMD, it uses a thermoset powder coating as the skin and a back injection of thermoplastic. This makes it technically more similar to a co-injection moulding technique used for in-mould painting and priming than a film or on-mould painting (using an open tool) technique. The component is painted on both sides. The commercial cost of IN-SPIRE compared to the co-injection technique,is lower since it does not require the purchase of a co-injection moulding machine.

There is no additional processing cost as there is with pre-manufactured films, foils or pre-forms. Here the technique would be more cost effective than other methods if considering a single colour alternative paint finish. Also, because the component is fully encapsulated by the paint layer, recyclate materials can be used as the substrate.

Layering it on

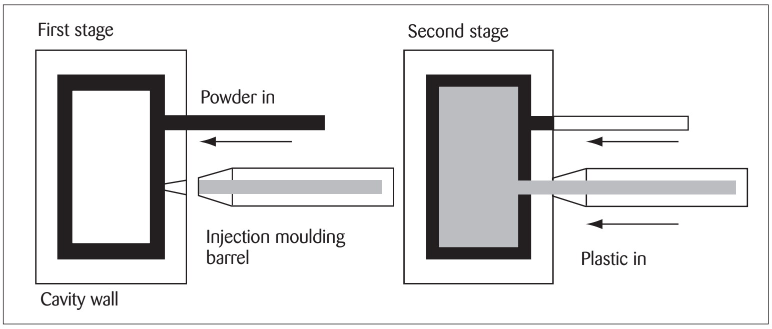
In trials, successful paint coverage of moulded components has been accompanied by the discovery that the paint thickness can be well defined over the whole surface and is of the order 10-20μm, depending on the particle size. Techniques such as the use of a high speed camera enables researchers to capture and refine the distribution of the powder as it 'explodes' into the mould cavity.

Correct thickness of the paint film can be built up by rapid fire of subsequent layers. With the IN-SPIRE technique, this control applies to many layers of different materials. This offers a technological platform for a new and advanced process that provides a step wise change to plastic manufacturing processes.

While the process has been limited to single colour applications, a number of potential uses are being investigated. These include multi-colour and multi-layering applications for decoration. This has been likened to a Gatling gun injector. Layers can be on top of each other or side by side so that different colours and effects can be achieved, or a series of layers can be applied, for example, for colour hard coats.

Multi-layering of a number of materials to produce unique sensors in mouldings is in its early stages. Research at Warwick has shown that polar particles such as pigment components can be manipulated and manoeuvred during the injection moulding process by external forces. Examples have been produced to demonstrate the effects with pigments.

This polar manipulation technique could be applied during the IN-SPIRE process. Different thin layers of materials can be sprayed sequentially to produce layers with smart properties, for example, to create sensors on the surface of a body panel or to build in conductive tracking by manipulative coating of the pigment materials onto selective sites. This could be extended to the creation of many smart surfaces on moulded car parts.



Schematic of the IN-SPIRE process

Further information

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